

DOT POINT

VISIT...

IB CHEMISTRY OPTIONS



et Hogan •

S

Science Press

© Science Press 2010
First published 2010

Science Press
Private Bag 7023 Marrickville NSW 1475 Australia
Tel: +61 2 9516 1122 Fax: +61 2 9550 1915
sales@sciencepress.com.au
www.sciencepress.com.au

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise, without the prior permission of Science Press. ABN 98 000 073 861

Copyright statements © IBO 2007 refer to the syllabus guide published by the International Baccalaureate Organization.

Thanks to the International Baccalaureate Organization for permission to reproduce its intellectual property.

This material has been developed independently by the publisher and the content is in no way connected with or endorsed by the International Baccalaureate Organization.



Contents

Introduction	v
Command Terms and Verbs to Watch	vi

Dot Points

Modern Analytical Chemistry	vii
Human Biochemistry	ix
Chemistry in Industry and Technology	xi
Medicine and Drugs	xiii
Environmental Chemistry	xv
Food Chemistry	xvii
Further Organic Chemistry	xix

Questions

Modern Analytical Chemistry	1
Human Biochemistry	47
Chemistry in Industry and Technology	107
Medicine and Drugs	181
Environmental Chemistry	229
Food Chemistry	299
Further Organic Chemistry	337

Answers

Modern Analytical Chemistry	375
Human Biochemistry	393
Chemistry in Industry and Technology	421
Medicine and Drugs	451
Environmental Chemistry	471
Food Chemistry	499
Further Organic Chemistry	511

Appendices

Data Sheets	527
Periodic Table	548
Index	549

What the book includes

This book provides questions and answers for each dot point in the IB Chemistry Options syllabus from the International Baccalaureate Diploma Programme for Chemistry:

- Modern Analytical Chemistry
- Human Biochemistry
- Chemistry in Industry and Technology
- Medicine and Drugs
- Environmental Chemistry
- Food Chemistry
- Further Organic Chemistry

Format of the book

The book has been formatted in the following way:

1.1 Subtopic from syllabus.

1.1.1 Assessment statement from syllabus.

1.1.1.1 First question for this assessment statement.

1.1.1.2 Second question for this assessment statement.

The number of lines provided for each answer gives an indication of how many marks the question might be worth in an examination. As a rough rule, every two lines of answer might be worth 1 mark.

How to use the book

Completing all questions will provide you with a summary of all the work you need to know from the syllabus. You may have done work in addition to this with your teacher as extension work. Obviously this is not covered, but you may need to know this additional work for your school exams.

When working through the questions, write the answers you have to look up in a different colour to those you know without having to research the work. This will provide you with a quick reference for work needing further revision.

Command Terms and Verbs to Watch

account, account for State reasons for, report on, give an account of, narrate a series of events or transactions.

analyse Interpret data to reach conclusions.

annotate Add brief notes to a diagram or graph.

apply Use an idea, equation, principle, theory or law in a new situation.

assess Make a judgement of value, quality, outcomes, results or size.

calculate Find a numerical answer showing the relevant stages in the working (unless instructed not to do so).

clarify Make clear or plain.

classify Arrange into classes, groups or categories.

comment Give a judgement based on a given statement or result of a calculation.

compare Give an account of similarities and differences between two (or more) items, referring to both (all) of them throughout.

construct Represent or develop in graphical form.

contrast Show how things are different or opposite.

deduce Reach a conclusion from the information given.

define Give the precise meaning of a word, phrase or physical quantity.

demonstrate Show by example.

derive Manipulate a mathematical relationship(s) to give a new equation or relationship.

describe Give a detailed account.

design Produce a plan, simulation or model.

determine Find the only possible answer.

discuss Give an account including, where possible, a range of arguments for and against the relative importance of various factors, or comparisons of alternative hypotheses.

distinguish Give differences between two or more different items.

draw Represent by means of pencil lines.

estimate Find an approximate value for an unknown quantity.

evaluate Assess the implications and limitations.

examine Inquire into.

explain Give a detailed account of causes, reasons or mechanisms.

extract Choose relevant and/or appropriate details.

extrapolate Infer from what is known.

identify Find an answer from a given number of possibilities.

justify Support an argument or conclusion.

label Add labels to a diagram.

list Give a sequence of names or other brief answers with no explanation.

measure Find a value for a quantity.

outline Give a brief account or summary.

predict Give an expected result.

propose Put forward a point of view, idea, argument, suggestion etc for consideration or action.

recall Present remembered ideas, facts or experiences.

show Give the steps in a calculation or derivation.

sketch Represent by means of a graph showing a line and labelled but unscaled axes but with important features (for example, intercept) clearly indicated.

solve Obtain an answer using algebraic and/or numerical methods.

state Give a specific name, value or other brief answer without explanation or calculation.

suggest Propose a hypothesis or other possible answer.

summarise Express concisely the relevant details.

synthesise Put together various elements to make a whole.

Modern Analytical Chemistry

Dot Point	Page	Dot Point	Page
Core material: A1-A7 are core material for SL and HL.			
Extension material: A8-A10 are extension material for HL only.			
A1 Analytical techniques	3	A7 Chromatography	29
A.1.1 Reasons for analysis.	3	A.7.1 Uses for chromatography.	29
A.1.2 Using information from analytical techniques.	4	A.7.2 Chromatographic techniques, adsorption and partition.	30
A2 Principles of spectroscopy	5	A.7.3 Paper, thin-layer and column chromatography.	31
A.2.1 The electromagnetic spectrum.	5	HL A8 Visible and ultraviolet (UV-Vis) spectroscopy	35
A.2.2 Absorption and emission spectra.	6	A.8.1 Transition metal complexes, splitting d orbitals.	35
A.2.3 Processes involving absorption.	9	A.8.2 Colour of transition metal complexes.	35
A3 Infra-red (IR) spectroscopy	11	A.8.3 Double bonds in organic compounds absorb UV radiation.	36
A.3.1 The double-beam IR spectrometer.	11	A.8.4 Conjugation of double bonds and wavelength of absorbed light.	36
A.3.2 Using an IR spectrum to identify bonds.	12	A.8.5 Predicting the absorption of light.	38
A.3.3 Molecular changes during absorption of IR radiation.	12	A.8.6 Calibration curves and the Beer-Lambert law.	39
A.3.4 Analysis of IR spectra of organic molecules.	14	HL A9 Nuclear magnetic resonance (NMR) spectroscopy	41
A4 Mass spectrometry	17	A.9.1 Tetramethylsilane as a reference standard.	41
A.4.1 Molecular mass determined from molecular ion peak.	17	A.9.2 Analysis of ^1H NMR spectra.	42
A.4.2 Fragmentation patterns in a mass spectrum.	18	HL A10 Chromatography	45
A5 Nuclear magnetic resonance (NMR) spectroscopy	21	A.10.1 Gas-liquid (GLC) and high-performance (HPLC) liquid chromatography.	45
A.5.1 Deductions from a ^1H NMR spectrum.	21	A.10.2 Selecting an appropriate chromatographic technique.	46
A.5.2 Using NMR in body scanners.	22	Answers to Modern Analytical Chemistry	375
A6 Atomic absorption (AA) spectroscopy	23		
A.6.1 Uses of AA spectroscopy.	23		
A.6.2 Principles of atomic absorption.	24		
A.6.3 Components of the AA spectrophotometer.	24		
A.6.4 Calibration curves and concentration of solutions.	25		

[illegible]

Human Biochemistry

Dot Point	Page	Dot Point	Page
Core material: B1-B6 are core material for SL and HL.			
Extension material: B7-B9 are extension material for HL only.			
B1 Energy	49	B.4.9 Importance of lipids in the body.	80
B.1.1 Energy value of foods.	49	B5 Micronutrients and macronutrients	81
B2 Proteins	51	B.5.1 Micronutrients and macronutrients.	81
B.2.1 General formula of 2-amino acids.	51	B.5.2 Retinol, calciferol and ascorbic acid.	82
B.2.2 Properties of 2-amino acids.	52	B.5.3 Solubility of vitamins.	82
B.2.3 Condensation reaction of 2-amino acids.	53	B.5.4 Nutrient deficiencies.	83
B.2.4 Structure of proteins.	55	B6 Hormones	85
B.2.5 Analysis of proteins by chromatography and electrophoresis.	59	B.6.1 Hormones, production and functions.	85
B.2.6 Functions of proteins.	62	B.6.2 Cholesterol and sex hormones.	87
B3 Carbohydrates	63	B.6.3 Oral contraceptives.	88
B.3.1 Structure of monosaccharides.	63	B.6.4 Steroids, use and abuse.	89
B.3.2 Glucose and fructose.	64	HL B7 Enzymes	91
B.3.3 Condensation of monosaccharides.	65	B.7.1 Biological catalysts (enzymes).	91
B.3.4 Functions of carbohydrates.	68	B.7.2 Comparing inorganic and biological catalysts.	92
B.3.5 Comparing starch and cellulose.	69	B.7.3 Substrate concentration and enzyme activity.	93
B.3.6 Dietary fibre.	69	B.7.4 Determining $V_{\max}$ and Michaelis constant (K_m).	94
B.3.7 Dietary fibre in the diet.	70	B.7.5 Mechanism of enzyme action.	95
B4 Lipids	71	B.7.6 Competitive and non-competitive inhibition.	96
B.4.1 Types of lipids.	71	B.7.7 Enzyme activity, effects of heavy-metal ions, temperature and pH.	98
B.4.2 Comparing HDL and LDL cholesterol.	73	HL B8 Nucleic acids	99
B.4.3 Saturated and unsaturated fatty acids.	74	B.8.1 Nucleotides and their condensation polymers.	99
B.4.4 Comparing linoleic and linolenic fatty acids.	75	B.8.2 Structures of DNA and RNA.	101
B.4.5 Iodine number and C=C double bonds.	76	B.8.3 The double helix and DNA.	101
B.4.6 Condensation of glycerol and fatty acids.	77	B.8.4 DNA in genetics and protein synthesis.	102
B.4.7 Hydrolysis of glycerol.	78	B.8.5 DNA profiling.	103
B.4.8 Energy values of fats and carbohydrates.	79	HL B9 Respiration	105
		B.9.1 Aerobic and anaerobic respiration of glucose.	105
		B.9.2 Copper ions in electron transport and iron ions in oxygen transport.	106
		Answers to Human Biochemistry	393

Chemistry in Industry and Technology

Dot Point	Page	Dot Point	Page
Core material: C1-C7 are core material for SL and HL.			
Extension material: C8-C12 are extension material for HL only.			
C1 Iron, steel and aluminium	109	C6 Liquid crystals	149
C.1.1 Sources of iron.	109	C.6.1 Liquid crystals.	149
C.1.2 The blast furnace.	111	C.6.2 Thermotropic and lyotropic liquid crystals.	150
C.1.3 Iron to steel, the basic oxygen converter.	114	C.6.3 Thermotropic liquid crystals.	152
C.1.4 Alloys, a homogeneous mixture.	115	C.6.4 The liquid-crystal display.	152
C.1.5 Properties of alloys.	116	C.6.5 Liquid crystals, properties and uses.	153
C.1.6 Heat treatment of steel.	117	C7 Nanotechnology	155
C.1.7 Iron and steel, properties and uses.	117	C.7.1 Nanotechnology.	155
C.1.8 Aluminium production.	119	C.7.2 Manipulating atoms.	155
C.1.9 Aluminium and its alloys, properties and uses.	121	C.7.3 Carbon nanotubes.	156
C.1.10 Iron and aluminium production, environmental impact.	123	C.7.4 Implications of nanotechnology.	157
C2 The oil industry	127	HL C8 Condensation polymers	159
C.2.1 Oil, an energy source and chemical feedstock.	127	C.8.1 Addition and condensation polymers.	159
C.2.2 Cracking of petroleum.	128	C.8.2 Formation of condensation polymers.	160
C3 Addition polymers	131	C.8.3 Polymers, properties and structure.	162
C.3.1 Polymers, properties and structures.	131	C.8.4 Modifying properties of polymers.	163
C.3.2 Addition polymers, modifying properties.	133	C.8.5 Advantages and disadvantages of polymer use.	163
C.3.3 Polymers, advantages and disadvantages.	134	HL C9 Mechanisms in the organic chemicals industry	165
C4 Catalysts	137	C.9.1 Manufacture of low-density polyethene.	165
C.4.1 Homogeneous and heterogeneous catalysts, modes of action.	137	C.9.2 Manufacture of high-density polyethene.	165
C.4.2 Catalysts, advantages and disadvantages.	140	HL C10 Silicon and photovoltaic cells	167
C.4.3 Choosing a catalyst.	141	C.10.1 Doping silicon.	167
C5 Fuel cells and rechargeable batteries	143	C.10.2 Sunlight and semiconductors.	168
C.5.1 Hydrogen-oxygen fuel cell.	143	HL C11 Liquid crystals	169
C.5.2 Rechargeable batteries.	145	C.11.1 Explaining liquid-crystal behaviour.	169
C.5.3 Comparing fuel cells and rechargeable batteries.	147	C.11.2 Twisted nematic liquid crystals.	170
		C.11.3 Kevlar.	171
		HL C12 The chlor-alkali industry	173
		C.12.1 Electrolysis of sodium chloride.	173
		C.12.2 Uses of the products of sodium chloride electrolysis.	180
		C.12.3 Environmental impact of sodium chloride electrolysis.	180
		Answers to Chemistry in Industry and Technology	421

Medicine and Drugs

Dot Point	Page	Dot Point	Page
Core material: D1-D7 are core material for SL and HL.			
Extension material: D8-D10 are extension material for HL only.			
D1 Pharmaceutical products	183	D6 Antibacterials	211
D.1.1 Medicines and drugs, effects on body functioning.	183	D.6.1 Penicillin, historical development.	211
D.1.2 Pharmaceutical products, research, development and testing.	185	D.6.2 Penicillin, how it works.	213
D.1.3 Administering drugs.	186	D.6.3 Penicillin overprescription.	214
D.1.4 Therapeutic window, tolerance and side effects of drugs.	190	D7 Antivirals	215
D2 Antacids	191	D.7.1 Viruses and bacteria.	215
D.2.1 Reducing excess stomach acidity.	191	D.7.2 Antiviral drugs.	215
D3 Analgesics	193	D.7.3 AIDS.	216
D.3.1 Analgesics prevent pain.	193	HL D8 Drug action	217
D.3.2 Pain relief by aspirin and paracetamol.	194	D.8.1 Geometrical isomers in drugs.	217
D.3.3 Morphine, codeine and diamorphine (heroin).	195	D.8.2 Chirality in drugs.	217
D.3.4 Morphine and its derivatives, advantages and disadvantages.	196	D.8.3 Penicillin, beta-lactam ring.	218
D4 Depressants	199	D.8.4 Potency of heroin and morphine.	219
D.4.1 Effects of depressants.	199	HL D9 Drug design	221
D.4.2 Ethanol, effects of use and abuse.	200	D.9.1 The compound library and drug design.	221
D.4.3 Detecting ethanol.	202	D.9.2 Synthesis of new drugs.	221
D.4.4 Synergistic effects of ethanol.	204	D.9.3 Computers and drug design.	222
D.4.5 Depressants.	205	D.9.4 Polarity, aqueous solubility and drug transport.	223
D5 Stimulants	207	D.9.5 Chiral auxiliaries and enantiomers.	223
D.5.1 Physiological effects of stimulants.	207	HL D10 Mind-altering drugs	225
D.5.2 Amphetamines and epinephrine.	207	D.10.1 LSD, mescaline, psilocybin and THC.	225
D.5.3 Nicotine.	208	D.10.2 Comparing LSD, mescaline and psilocybin.	226
D.5.4 Caffeine compared with nicotine.	209	D.10.3 Legalisation of cannabis.	227
		Answers to Medicine and Drugs	451

Environmental Chemistry

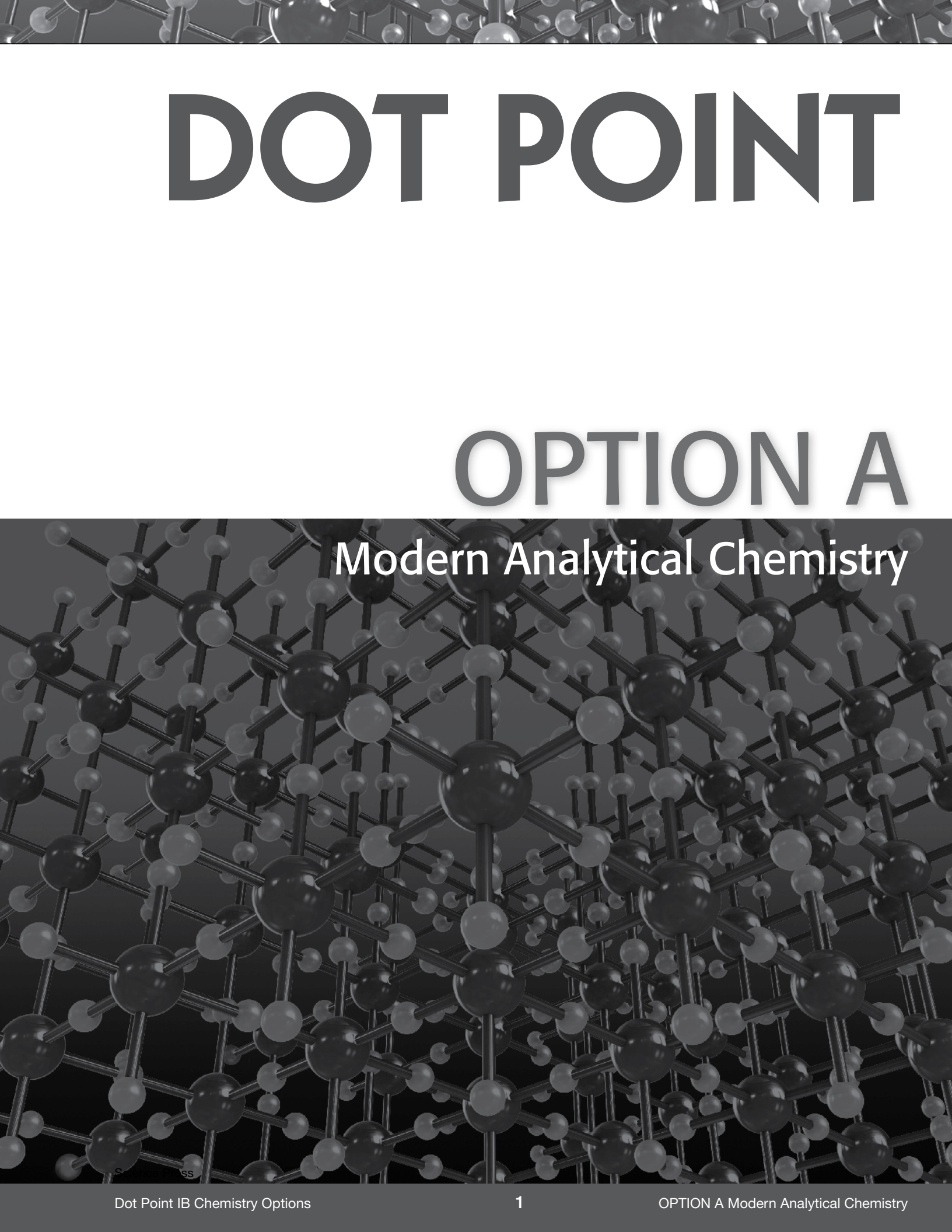
Dot Point	Page	Dot Point	Page
Core material: E1-E8 are core material for SL and HL.			
Extension material: E9-E12 are extension material for HL only.			
E1 Air pollution	231	E8 Waste	281
E.1.1 Atmospheric pollution.	231	E.8.1 Waste disposal.	281
E.1.2 Reduction of air pollution.	236	E.8.2 Recycling.	282
E2 Acid deposition.	239	E.8.3 Radioactive waste.	283
E.2.1 Acid deposition.	239	E.8.4 Storage and disposal of radioactive waste.	285
E.2.2 Acid deposition, effects and reduction.	240	HL E9 Ozone depletion	287
E3 Greenhouse effect	243	E.9.1 Dissociation of O ₂ and O ₃ .	287
E.3.1 The greenhouse effect.	243	E.9.2 Catalysis of ozone depletion.	287
E.3.2 Greenhouse gases.	244	E.9.3 Ozone depletion in polar regions.	288
E.3.3 Increase in greenhouse gases.	246	HL E10 Smog	289
E4 Ozone depletion	251	E.10.1 Photochemical smog and primary pollutants.	289
E.4.1 Ozone in the stratosphere.	251	E.10.2 Photochemical smog and secondary pollutants.	290
E.4.2 Ozone-depleting pollutants.	254	HL E11 Acid deposition	291
E.4.3 Alternatives to CFCs.	257	E.11.1 Acid deposition, role of NO _x and SO _x .	291
E5 Dissolved oxygen in water	259	E.11.2 Acid deposition and ammonia.	291
E.5.1 Biochemical oxygen demand (BOD).	259	HL E12 Water and soil	293
E.5.2 Decomposition of organic matter in water.	259	E.12.1 Chemical precipitation and soil.	293
E.5.3 Eutrophication.	260	E.12.2 Cation-exchange capacity (CEC).	295
E.5.4 Thermal pollution.	263	E.12.3 Effects of soil pH.	296
E6 Water treatment	265	E.12.4 Functions of soil organic matter (SOM).	297
E.6.1 Primary pollutants in water.	265	Answers to Environmental Chemistry	471
E.6.2 Waste water treatment.	266		
E.6.3 Fresh water from sea water.	269		
E7 Soil	275		
E.7.1 Soil degradation.	275		
E.7.2 Soil organic matter.	278		
E.7.3 Organic soil pollutants.	279		

Food Chemistry

Dot Point	Page	Dot Point	Page
Core material: F1-F6 are core material for SL and HL.			
Extension material: F7-F10 are extension material for HL only.			
F1 Food groups	301	F4 Colour	313
F.1.1 Food and nutrients.	301	F.4.1 Dyes and pigments.	313
F.1.2 Lipids, carbohydrates and proteins.	301	F.4.2 Colour in natural pigments.	313
F2 Fats and oils	303	F.4.3 The pigments anthocyanins, carotenoids, chlorophyll and haem.	314
F.2.1 Saturated and unsaturated fatty acids.	303	F.4.4 Colour stability of pigments.	314
F.2.2 Properties and structure of fats and oils.	304	F.4.5 Synthetic food colours and safety.	315
F.2.3 Stability of fats and oils.	305	F.4.6 Non-enzymatic browning and caramelisation of food.	316
F.2.4 Hydrogenation of unsaturated fats, process.	305	F5 Genetically modified foods	319
F.2.5 Hydrogenation of unsaturated fats, advantages and disadvantages.	305	F.5.1 Genetically modified (GM) food.	319
F3 Shelf life	307	F.5.2 Benefits and concerns of GM food.	319
F.3.1 Shelf life.	307	F6 Texture	321
F.3.2 Shelf life and food quality.	307	F.6.1 Dispersed food systems.	321
F.3.3 Rancidity of fats.	307	F.6.2 Suspensions, emulsions and foams.	321
F.3.4 Hydrolytic and oxidative rancidity of lipids.	308	F.6.3 Action of emulsifiers.	324
F.3.5 Minimising rancidity and prolonging shelf life.	308	HL F7 Oxidative rancidity (auto-oxidation)	327
F.3.6 Cultural methods to extend shelf life of foods.	309	F.7.1 Steps in oxidative rancidity.	327
F.3.7 Antioxidants.	310	HL F8 Antioxidants	329
F.3.8 Naturally occurring antioxidants.	310	F.8.1 Types of antioxidants.	329
F.3.9 Synthetic antioxidants in food.	310	HL F9 Stereochemistry in food	331
F.3.10 Comparing natural and synthetic antioxidants.	311	F.9.1 Naming enantiomeric forms.	331
F.3.11 Antioxidants in foods of different cultures.	311	F.9.2 Stereoisomers in food.	331
		HL F10 Chemical structure and colour	333
		F.10.1 Comparing natural pigments.	333
		F.10.2 Reason for colour of organic molecules.	334
		F.10.3 Solubility of anthocyanins and carotenoids.	335
		Answers to Food Chemistry	499

Further Organic Chemistry

Dot Point	Page	Dot Point	Page
Core material: G1-G8 are core material for SL and HL. Extension material: G9-G11 are extension material for HL only.		G8 Acid-base reactions	355
G1 Electrophilic addition reactions	339	G.8.1 Acidic properties and bonding of phenol and substituted phenols.	355
G.1.1 Electrophilic addition mechanisms.	339	G.8.2 Acidic properties and bonding of substituted carboxylic acids.	356
G.1.2 Stabilities of carbocations.	340	G.8.3 Relative basicities of ammonia and amines.	356
G2 Nucleophilic addition reactions	341	HL G9 Addition-elimination reactions	359
G.2.1 Addition of HCN to aldehydes and ketones.	341	G.9.1 Acid anhydride reactions with nucleophiles.	359
G.2.2 Mechanism for addition of HCN to aldehydes and ketones.	341	G.9.2 Acyl chloride reactions with nucleophiles.	361
G.2.3 Hydrolysis of cyanohydrins to form carboxylic acids.	342	G.9.3 Addition-elimination mechanism.	363
G3 Elimination reactions	343	HL G10 Electrophilic substitution reactions	365
G.3.1 Dehydration of alcohols.	343	G.10.1 Nitration, chlorination, alkylation and acylation of benzene.	365
G.3.2 Mechanism for elimination of water from alcohols.	343	G.10.2 Mechanisms for benzene electrophilic substitution reactions.	366
G4 Addition-elimination reactions	345	G.10.3 Nitration, chlorination, alkylation and acylation of methylbenzene.	367
G.4.1 Aldehydes and ketones react with 2,4-dinitrophenylhydrazine.	345	C.10.4 Directing effects and reaction rates for benzene ring substituents.	369
G5 Arenes	347	HL G11 Reaction pathways	371
G.5.1 Structure of benzene.	347	G.11.1 Deducing reaction pathways.	371
G.5.2 Hydrolysis of benzene compounds.	348	Answers to Further Organic Chemistry	511
G6 Organometallic chemistry	349		
G.6.1 Formation of Grignard reagents.	349		
G.6.2 Reactions of Grignard reagents.	349		
G7 Reaction pathways	351		
G.7.1 Deducing reaction pathways.	351		



DOT POINT

OPTION A

Modern Analytical Chemistry

A.1.1 State the reasons for using analytical techniques. © IBO 2007**A.1.1.1** Analysis is very important in chemistry.

(a) What is chemical analysis?

.....

.....

(b) Identify properties of a substance which might be measured as part of a chemical analysis.

.....

.....

A.1.1.2 There are many possible reasons for using analytical techniques. Suggest some of these reasons.

.....

.....

.....

.....

.....

.....

A.1.1.3 Analytical techniques can be qualitative or quantitative. Explain the difference.

.....

.....

.....

.....

A.1.2 State that the structure of a compound can be determined by using information from a variety of analytical techniques singularly or in combination. © IBO 2007

A.1.2.1 Different analytical techniques provide different information about the structure of a compound. Complete the table to illustrate this point.

Technique	Information that can be obtained using this technique	Information that cannot be obtained using this technique
Mass spectrometry		
UV-visible spectroscopy		
NMR spectroscopy		
Chromatography		
Infra-red spectrometry		
Atomic absorption spectroscopy (AAS)		

A.1.2.2 Information derived from using only one technique is usually insufficient to determine the structure of a substance. Describe an example of this.

.....

.....

.....

.....

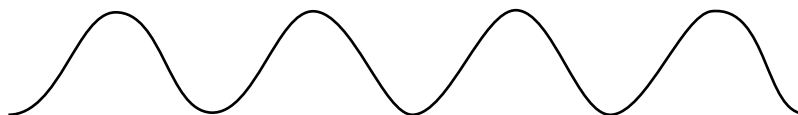
.....

.....

.....

A.2.1 Describe the electromagnetic spectrum. © IBO 2007**A.2.1.1** You will recall from your Core studies that a wave is a method of transferring energy.

(a) Waves vary in wavelength. Label the diagram below to show the wavelength of this wave.



(b) Waves also vary in frequency. How could you define the frequency of a wave?

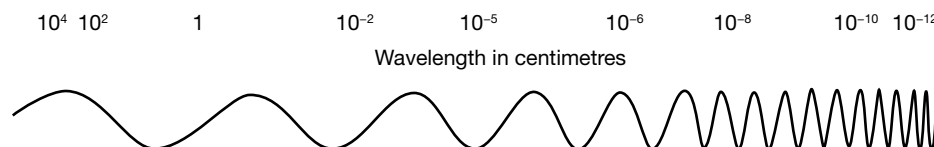
.....

.....

(c) How is the frequency of a wave related to the amount of energy it carries?

.....

.....

A.2.1.2 Electromagnetic radiation consists of a series (spectrum) of waves produced by the movement of electrically charged particles. These waves can vary in wavelength, frequency and the amount of energy they carry. The diagram below represents the electromagnetic spectrum.

(a) On the diagram above, use arrows to show the direction of increase across this spectrum of wavelength, frequency and amount of energy carried. Then add labels to show the positions in the spectrum of the main types of electromagnetic radiation.

(b) Compare the velocity of different types of electromagnetic radiation.

.....

.....

(c) Use an equation to show the mathematical relationship between the velocity, frequency and wavelength of electromagnetic radiation.

.....

.....

A.2.1.3 The following objects could be used to model the relative wavelengths of different types of electromagnetic radiation.

An atom, the nucleus of an atom, a virus particle, a soccer field, a full stop (.), the tip of a pin, a butterfly.

Place these examples into the appropriate spaces in the table below.

Type of radiation	Representing the size of the wavelength
Radio waves	
Microwaves	
Infra-red	
Visible light	
Ultraviolet	
X-rays	
Gamma rays	

A.2.2 Distinguish between absorption and emission spectra and how each is produced. © IBO 2007

A.2.2.1 Visible light is only one small part of the whole electromagnetic spectrum.

(a) Describe what constitutes visible light.

.....

.....

.....

.....

.....

(b) Explain why objects appear coloured in visible light.

.....

.....

.....

A.2.2.2 Define the following terms.

(a) Spectroscopy.

.....

.....

(b) Spectrometer.

.....

.....

(c) Spectrum.

.....

.....

A.2.2.3 In your Core studies you examined three types of spectra, continuous, emission and line spectra.

(a) Complete the table to compare continuous, absorption and emission spectra.

Factor	Continuous spectra	Absorption spectra	Emission spectra
Composed of			
Produced by			

(b) Draw an emission and an absorption spectrum for a named element.

(c) Outline the relationship between lines of emission and absorption in spectra.

.....

.....

.....



A.2.2.4 The pattern of lines in spectra is unique for a particular atom or molecule.

- (a) Within an atom, electrons are found in energy levels (orbitals). Outline the change in energy of electron orbitals as we move outwards from the nucleus.

.....

.....

- (b) If extra energy is supplied to an electron in an atom, will it move to an upper or a lower orbital?

.....

.....

- (c) How would you describe an electron which has moved to a higher orbit?

.....

- (d) Outline the origin of emission and absorption lines in spectra in terms of atomic structure.

.....

.....

.....

.....

.....

.....

.....

.....

.....

- (e) Explain why the spectra produced from electron transitions form a series of discrete (separate) lines at specific wavelengths, rather than a continuous spectrum of all wavelengths.

.....

.....

.....

A.2.2.5 Outline some uses of spectroscopy in analytical chemistry.

.....

.....

.....

.....

.....

.....

.....

.....

A.2.3 Describe the atomic and molecular processes in which absorption of energy takes place. © IBO 2007

A.2.3.1 Describe processes that can occur when an atom, or a molecule, absorbs energy.

.....

.....

.....

.....

.....

.....

A.2.3.2 Many fields of technology make use of the fact that matter can absorb energy transmitted by electromagnetic waves. Complete the table below to provide examples of the effect of different areas of the electromagnetic spectrum on matter.

EM region	Effect of EM radiation on atoms and/or molecules
Radio waves	
Microwaves	
Infra-red (IR)	
Visible light	
Ultraviolet (UV)	
X-ray	
Gamma radiation	

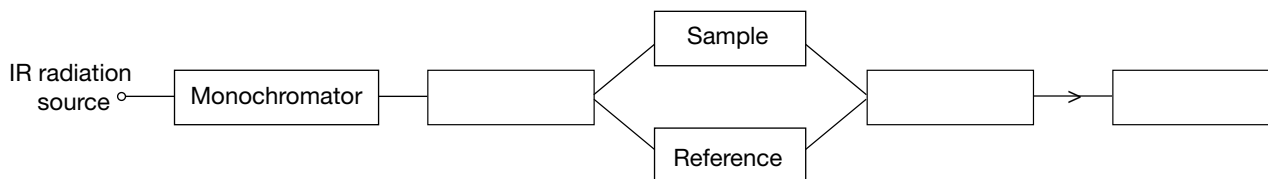


A.2.3.3 Complete the table to compare the process occurring when radiation from different regions of the electromagnetic spectrum is absorbed by atoms and molecules.

Region of EM spectrum being absorbed	Substance absorbing energy	Process when absorption occurs
Infra-red	A molecule of carbon dioxide	
Ultraviolet	A molecule of ethene	
X-rays	An atom of silver	
Visible region	A copper complex, $[\text{Cu}(\text{H}_2\text{O})]^{2+}$	

A.3.1 Describe the operating principles of a double-beam IR spectrometer. © IBO 2007**A.3.1.1** The diagram below shows a double-beam infra-red (IR) spectrometer.

(a) Label the beam splitter, detector and recorder.



(b) What does this machine do?

.....

.....

(c) What is the purpose of the beam splitter?

.....

.....

.....

(d) What is the purpose of the monochromator?

.....

(e) How is data collected from an IR scan normally presented to the analyst?

.....

.....

(f) What use does the analyst make of this information?

.....

.....

A.3.1.2 Modern infra-red spectrometers utilise a technique called Fourier transformation. What benefit does this technique provide for IR analysis compared with the IR spectrometer described in Question A.3.1.1?

.....

.....

.....

.....

.....

A.3.2 Describe how information from an IR spectrum can be used to identify bonds. © IBO 2007

A.3.2.1 Information from an IR spectrum can be used to identify bonds present as each type of bond present absorbs a different frequency of radiation, producing a different band on the spectrum.

- (a) In IR spectroscopy, reference is made to wave numbers rather than to frequency of electromagnetic radiation. What is meant by the wave number and why is it used in chemistry?

.....

.....

.....

.....

- (b) Calculate the wave number of infra-red radiation with a wavelength of 5×10^{-4} cm.

.....

.....

.....

- (c) Identify the relationship between the wave number of radiation and the amount of energy it carries.

.....

A.3.2.2 Identify two factors that could determine the way in which a bond will vibrate when exposed to infra-red radiation.

.....

.....

A.3.3 Explain what occurs at a molecular level during the absorption of IR radiation by molecules. © IBO 2007

A.3.3.1 Absorption of infra-red radiation can cause molecules to stretch, bend and vibrate when absorbed, thus changing the polarity of the molecule.

- (a) Identify the two main types of vibrational motion that can occur when IR radiation is absorbed by covalent bonds and indicate which requires more energy.

.....

.....

.....

- (b) Which of these two types of vibrational motion would be possible with each of the following?

(i) A triatomic molecule, e.g. CO_2 .

.....

.....

(ii) A diatomic molecule made of two elements, e.g. H-F.

.....

.....

(iii) A diatomic element, e.g. H_2 .

.....

.....

A.3.3.2 Use the information in the table below to deduce the relationship between the strength of a chemical bond and the energy needed to induce molecules to vibrate.

Molecule	Bond enthalpy (kJ mol ⁻¹)	Absorption (cm ⁻¹)
H-Cl	431	2886
H-Br	366	2559
H-I	299	2230

.....

.....

.....

.....

A.3.3.3 When molecules of carbon dioxide absorb IR radiation, they can undergo bending and asymmetric stretch, but not symmetrical stretch.

(a) Justify this statement.

.....

.....

.....

(b) Use labelled diagrams to show how the use of models can help to explain such statements.

.....

.....

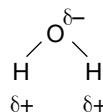
A.3.3.4 Use the infra-red data tables at the back of this book to help compare IR absorption for the C-H bond and the C=O bond.

.....

.....

.....

- A.3.3.5** Outline changes in polarity as stretching occurs in the water molecule and the significance of this in IR spectrometry.



A.3.4 Analyse IR spectra of organic compounds. © IBO 2007

- A.3.4.1** What is meant by the fingerprint region of an IR spectrum?

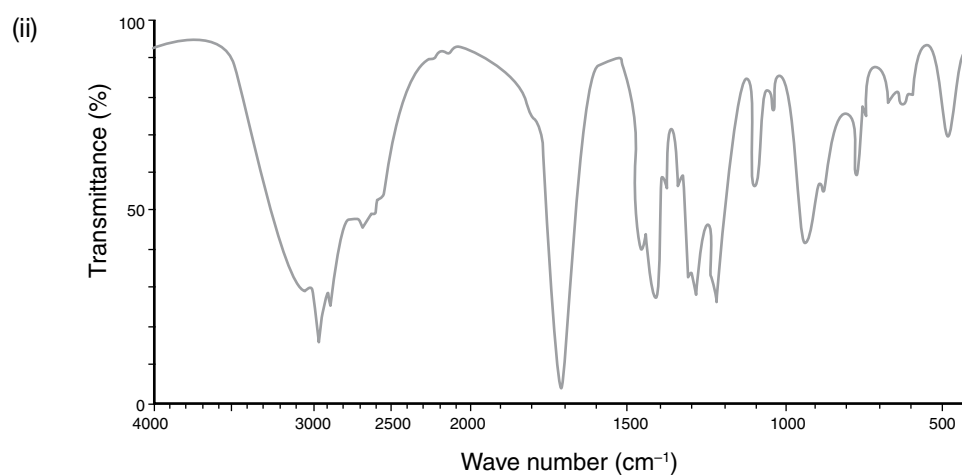
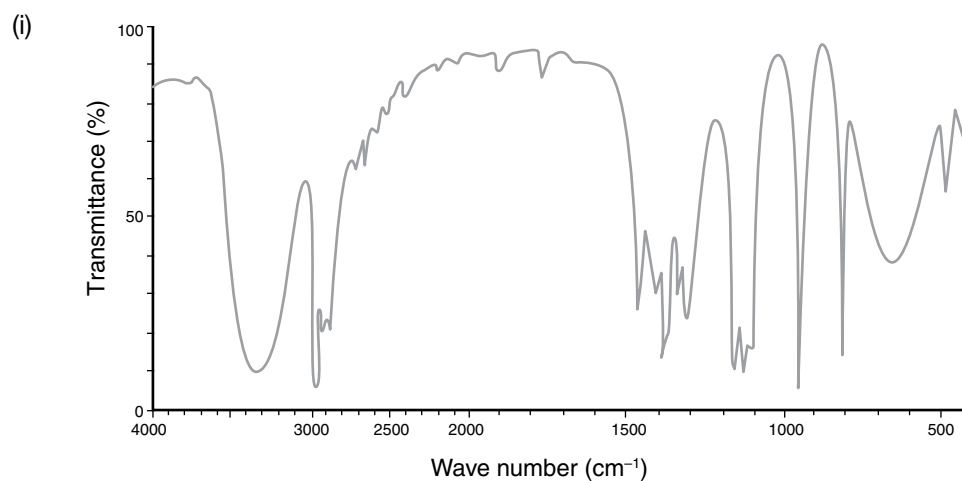
- A.3.4.2** A student studying an IR spectrum noticed strong absorption in the 1700 to 1750 cm^{-1} range. The student concluded that the compound was an ester. Discuss the validity of this conclusion.

A.3.4.3 The bands that appear in an IR spectrum depend on the types of bonds and the structure of the molecule.

- (a) Use the data sheets at the back of this book to complete the table below of the characteristic ranges of IR absorption due to stretching vibrations in organic molecules.

Bond	Wave number (cm^{-1})
C–O	
	2850 to 3100
C=O	
O–H	

- (b) Examine the IR spectra below. On each spectrum, label absorption bands which would indicate the presence of C–O, C–H, C=O and O–H bonds.



A.4.1 Determine the molecular mass of a compound from the molecular ion peak. © IBO 2007

A.4.1.1 Mass spectrometry is a technique used to separate ionised particles of different mass and to determine the amounts of each particle in a mixture.

- (a) Define a molecular ion and outline how you would identify it in a mass spectrum.

.....

.....

.....

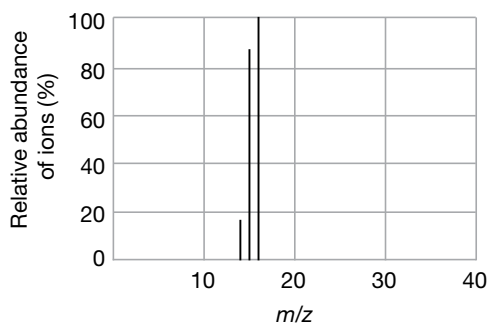
- (b) How is the molecular mass of a compound determined from the mass spectrogram?

.....

.....

- (c) A simplified mass spectrum for methane is provided below. Identify the source of the three peaks in this spectrum.

Simplified mass spectrum of methane

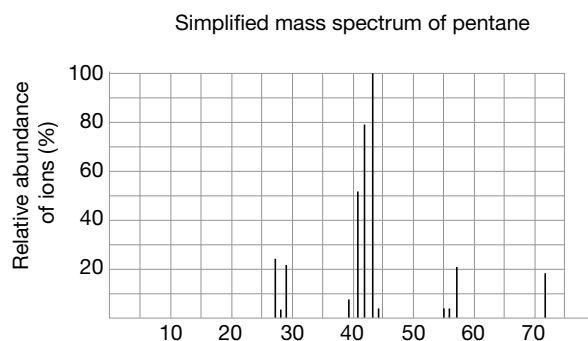


.....

.....

.....

- (d) Use the simplified mass spectrum of pentane shown below to comment on the claim that in a spectrum the molecular ion does not necessarily have the highest peak.



.....

.....

.....

.....

.....

- A.4.1.2** Comment on the stability of molecular ions formed in a mass spectrometer.

.....

.....

- A.4.1.3** Distinguish between the patterns of lines in the mass spectrum of an element and in the mass spectrum of a compound.

.....

.....

.....

- A.4.2** Analyse fragmentation patterns in a mass spectrum to find the structure of a compound. © IBO 2007

- A.4.2.1** The collision between gaseous molecules and the ionising electrons in the spectrometer causes fragmentation of the molecules, forming ions with different m/z ratio.

- (a) Outline how identification of the molecular ion in a spectrum of a compound can be used to determine a molecular formula.

.....

.....

.....

- (b) Outline how the pattern of fragments formed in the mass spectrometer can be used to identify a compound present.

.....

.....

.....

A.4.2.2 Use examples to show how the differences in m/z ratio between the fragments in a mass spectrometer can help identify the structure of the compound being analysed. Tabulate your answer.

.....

.....

.....

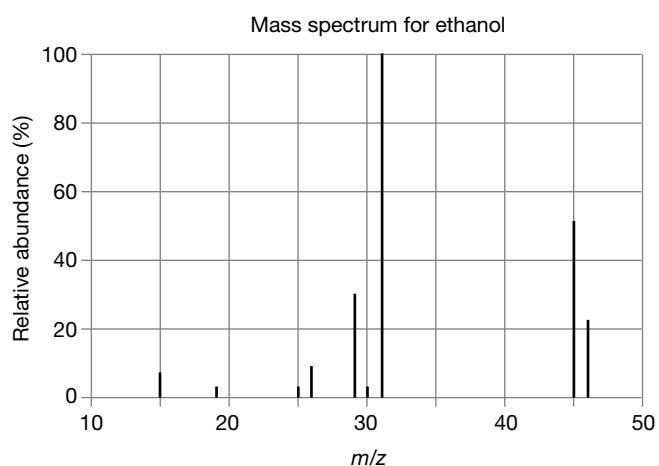
.....

.....

.....

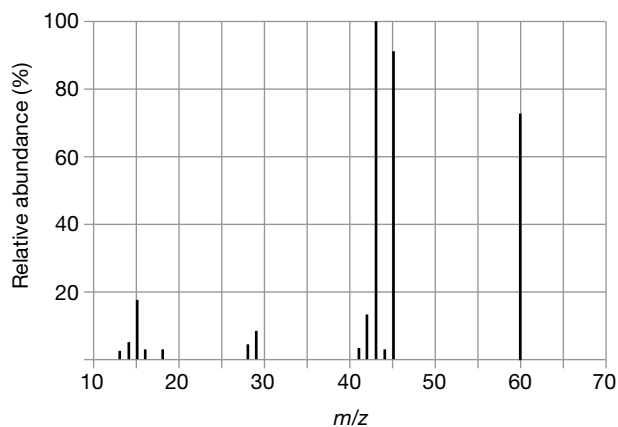
.....

A.4.2.3 Examine the spectrum below.



- (a) Identify the m/z peak which indicates the molecular mass (M_r) of the compound being analysed.
-
- (b) There is a peak at $m/z = 31$. Determine the molecular weight of the fragment that was lost and suggest a possible identity for this fragment.
-
- (c) Does the fragment that was lost have a charge, or is it neutral? Justify your answer.
-
-
- (d) Identify the fragment represented by the peak at 45.
-

A.4.2.4 Examine the spectrum below.



- (a) Determine the molecular mass of this compound.
- (b) Identify the ion represented by the peak at 45.
- (c) What does the peak at 43 indicate?
-
- (d) Infra-red spectroscopy analysis of this compound showed a strong absorption in the 1700 to 1750 cm^{-1} band. Deduce the identity of this compound, giving reasons.

.....

.....

.....

A.5.1 Deduce the structure of a compound given information from its ^1H NMR spectrum. © IBO 2007**A.5.1.1**

(a) What is nuclear magnetic resonance (NMR) spectroscopy?

.....

.....

.....

.....

(b) Identify information provided by a ^1H NMR spectrum.

.....

.....

.....

(c) Discuss uses of NMR spectroscopy that could be of benefit to society.

.....

.....

.....

.....

.....

(d) Explain what is meant by an integration trace and identify its purpose.

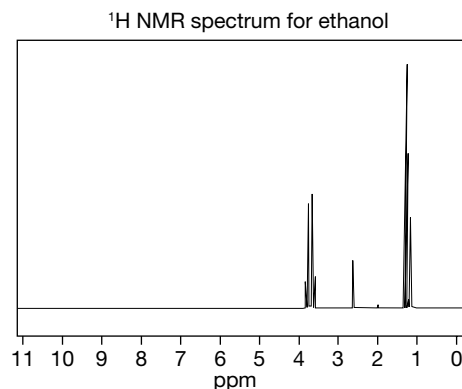
.....

.....

A.5.1.2 Using the data sheets at the back of this book, suggest a possible chemical environment for protons (hydrogen atoms) that correspond to the following signals in a ^1H NMR spectrum.

Chemical shift (ppm)	Chemical environment of protons
0.9 to 1.0	
2.5 to 3.5	
3.3 to 3.7	
9.4 to 10.0	

A.5.1.3 An ^1H NMR spectrum for ethanol is given below.



- (a) Determine the number of different types of hydrogen bonding environments present in this molecule and identify these environments.

.....

.....

.....

.....

.....

- (b) How would you expect the proton magnetic spectrum for ethanal to differ from the spectrum for ethanol shown above?

.....

.....

.....

.....

A.5.2 Outline how NMR is used in body scanners. © IBO 2007

A.5.2.1 The technique of magnetic resonance imaging (MRI) is being used with increasing frequency in medicine.

- (a) What information does this technique provide?

.....

.....

.....

.....

.....

- (b) Explain how body scanners used in hospitals are an application of nuclear magnetic resonance.

.....

.....

.....

.....

.....

A6 Atomic absorption (AA) spectroscopy. © IBO 2007

A.6.1 State the uses of AA spectroscopy. © IBO 2007

A.6.1.1 Atomic absorption spectroscopy (AAS) is an analytical technique which was developed in the 1950s by a team of Australian scientists led by Sir Alan Walsh. State the uses of AAS.

[illegible]

A.6.1.2 Atomic absorption spectroscopy represents a significant technological advance in analytical techniques. Justify this statement.

[illegible]

A.6.1.3 Discuss ways in which the development of atomic absorption spectroscopy has been beneficial to society.

[illegible]

A.6.2 Describe the principles of atomic absorption. © IBO 2007

A.6.2.1 Outline the principles behind the use of atomic absorption spectrometry.

.....

.....

.....

.....

A.6.2.2 Describe how the atomic absorption spectrometer uses these principles.

.....

.....

.....

.....

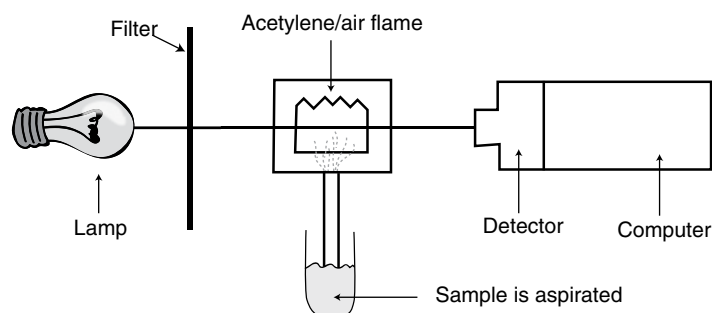
Answer Question A.6.2.3 by selecting the most correct alternative.

A.6.2.3 Which of the following pollutants can be detected using the technique of AAS?

- (A) Sulfur dioxide and sulfate ions.
- (B) Any pollution present in minute amounts.
- (C) Nitrates and ammonium ions.
- (D) Heavy metal ions.

A.6.3 Describe the use of each of the following components of the AA spectrophotometer: fuel, atomiser, monochromatic light source, monochromatic detector and readout. © IBO 2007

A.6.3.1 The diagram below represents an atomic absorption spectrometer.



Describe the use of the following components.

(a) The fuel.

.....

.....

.....

.....

.....



(b) The atomiser.

.....

.....

.....

(c) The monochromatic light source.

.....

.....

.....

.....

.....

(d) The monochromatic detector.

.....

.....

.....

(e) The readout.

.....

.....

.....

.....

A.6.4 Determine the concentration of a solution from a calibration curve. © IBO 2007

A.6.4.1

(a) Define the terms standard solution and absorbance.

.....

.....

.....

.....

(b) Describe the use of standard solutions in atomic absorption spectrometry (AAS).

.....

.....

.....

.....

(c) Describe the use of a calibration curve in AAS.

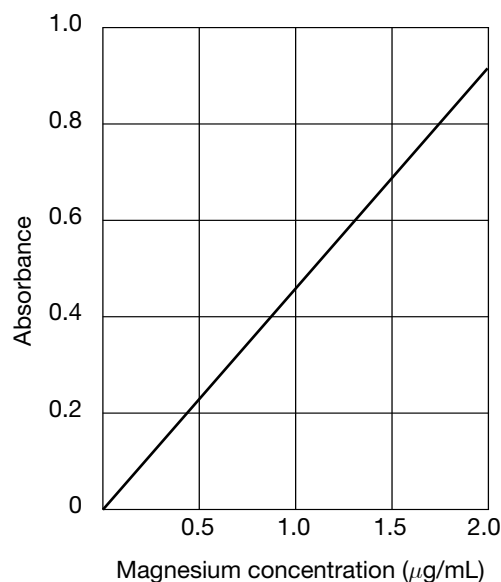
.....

.....

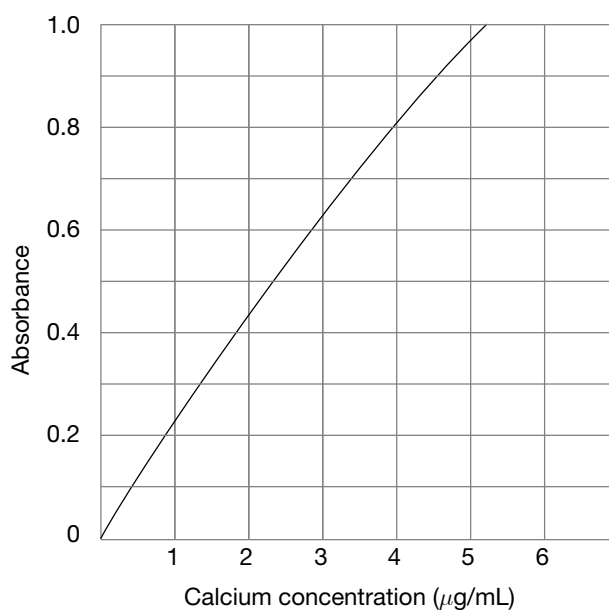
.....

.....

- A.6.4.2** A calibration curve was developed for magnesium using standard solutions of known concentration. A soil sample is analysed, using atomic absorption spectroscopy, for magnesium content. A solution made up from the soil sample is aspirated into the AAS and an absorbance reading of 0.8 is obtained. From the graph opposite, read off the concentration of magnesium in this solution.
-



- A.6.4.3** The graph below shows a calibration curve for calcium.



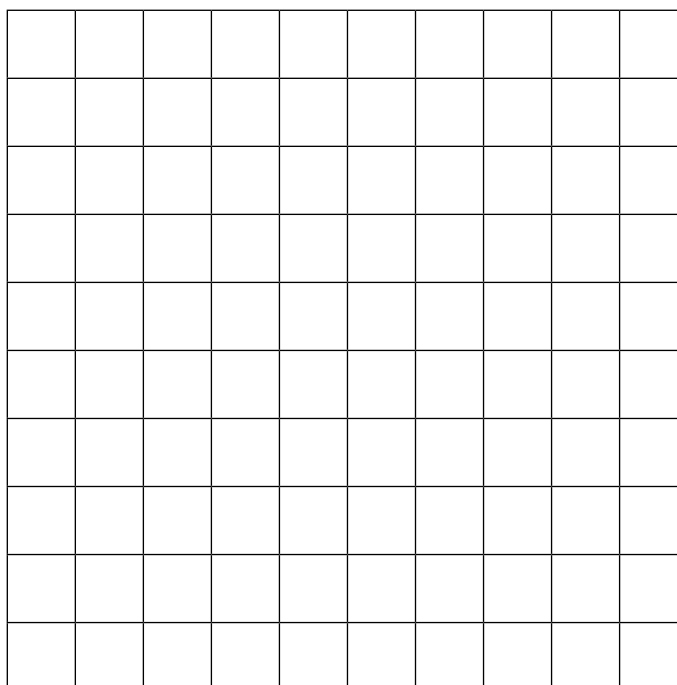
- (a) A centrifuged blood sample is being analysed for dissolved calcium. Its absorbance level is found, using AAS, to be 0.5. Use the calibration curve above to find the concentration of calcium in the sample.
-

- (b) Convert this value to ppm.
-
-
-
-

A.6.4.4

- (a) The following data was collected by using copper ion standards in an AAS with a wavelength setting of 327.4 nm. Construct a calibration curve on the grid provided using this data.

Concentration of copper ions in standard solutions (ppm)	Absorbance
0	0
1	0.19
2	0.33
4	0.58
6	0.75
8	0.85



- (b) Three samples of water from different locations in a river were analysed for the presence of copper pollution using atomic absorption spectrometry (AAS).
Using your calibration curve from part (a), determine the concentration of copper in ppm and in g/L in each of these samples if their absorbance readings were as follows.
- (i) 0.20
- (ii) 0.40
- (iii) 0.60
- (c) State an hypothesis to account for the variation in copper levels in different areas of the river.
-
-

© IBO 2007

[illegible][illegible][illegible]

A.7.2 Explain that all chromatographic techniques involve adsorption on a stationary phase and partition between a stationary phase and a mobile phase. © IBO 2007

A.7.2.1 Explain the main principle involved in chromatographic techniques. In your answer refer to the stationary and mobile phases.

.....

.....

.....

.....

A.7.2.2 Two processes involved in chromatography are adsorption and partition. Describe what is involved in each process.

(a) Adsorption.

.....

.....

.....

.....

(b) Partition.

.....

.....

.....

.....

A.7.2.3 Classify the following examples as involving adsorption or partition, justifying your answers.

(a) A glass column is packed with alumina (solid aluminium oxide). The sample to be analysed is poured into the column and continuously washed through with a solvent (elution). The components of the sample move down the column at different rates.

.....

.....

.....

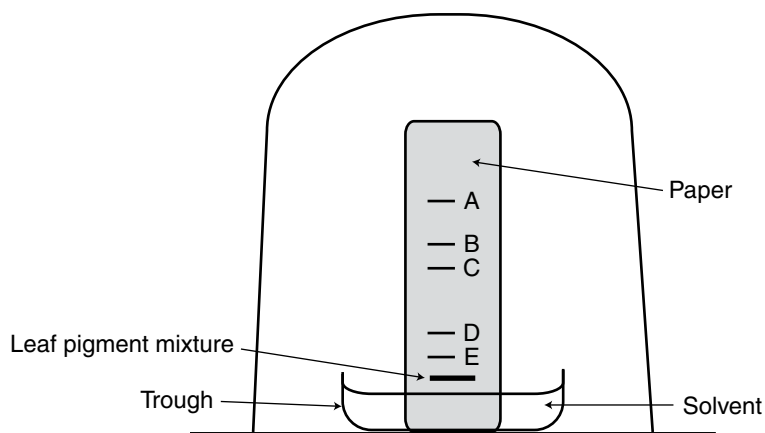
(b) Samples of different inks are placed at intervals along one end of a piece of absorbent paper, 2 cm from the end. This paper is then suspended so that it dips to a depth of 1 cm into a container of a liquid in which the inks are soluble. The components of each ink (the different dyes) move up the paper at different rates.

.....

.....

.....

- A.7.2.4** The diagram shows the separation of a mixture of five pigments (labelled A to E) from a green leaf by the process of chromatography. The mobile phase was cyclohexane and the stationary phase was paper (cellulose). Suggest a reason for the observed separation of pigments and deduce a property of the pigments that can account for their differential movement.



.....

.....

.....

.....

.....

.....

.....

- A.7.3** Outline the use of paper chromatography, thin-layer chromatography (TLC) and column chromatography. © IBO 2007

- A.7.3.1** Identify two uses for each of the named chromatographic processes.

Technique	Uses
Paper chromatography	
Thin-layer chromatography (TLC)	
Column chromatography	

A.7.3.2 Outline the processes of the following.

(a) Paper chromatography.

.....

.....

.....

.....

.....

.....

.....

(b) Thin-layer chromatography (TLC).

.....

.....

.....

.....

.....

.....

.....

A.7.3.3 A decimal fraction called the R_f factor can be used to identify components in a mixture when it undergoes paper or thin-layer chromatography.

(a) What is meant by the R_f value?

.....

.....

.....

.....

(b) Explain why the R_f value can never be greater than 1.

.....

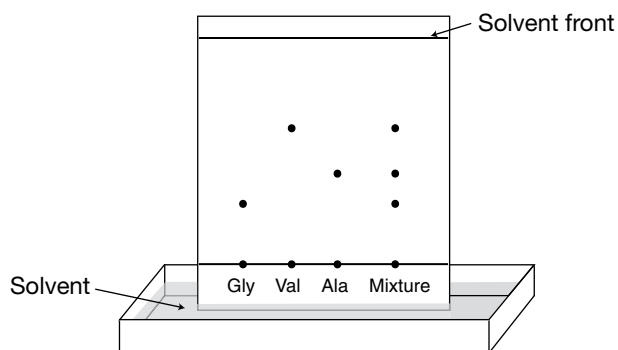
(c) Suggest reasons for variations in the observed R_f value for a particular chemical.

.....

.....

.....

A.7.3.4 The diagram below shows chromatography of a mixture of amino acids. Standards are supplied for the amino acids glycine, valine and alanine.



(a) Comment on the composition of the mixture.

.....

.....

(b) Calculate the R_f value for glycine.

.....

.....

A.7.3.5 Outline the process of column chromatography.

.....

.....

.....

.....

.....

.....

.....

.....

A.7.3.6 Many substances separated out by chromatography are colourless and require special techniques to detect their position. Outline two examples.

.....

.....

.....

.....

A.8.1 Describe the effect of different ligands on the splitting of the d orbitals in transition metal complexes. © IBO 2007

A.8.1.1 Transition metal complexes are often highly coloured and their colours depend upon the ligand present within the complex.

(a) Recall what is meant by a transition metal complex.

.....

.....

(b) Describe the effect of ligands on the splitting of the d orbitals in transition metal complexes.

.....

.....

.....

.....

(c) Account for the colour observed when light is absorbed by transition metals.

.....

.....

.....

.....

(d) Give an example of the effect of a ligand on the colour of a metal complex.

.....

.....

A.8.2 Describe the factors that affect the colour of transition metal complexes. © IBO 2007

A.8.2.1 Identify factors that affect the colour of transition metal complexes.

.....

.....

.....

A.8.2.2 Describe how ligands affect the colour of transition metal complexes.

.....

.....

.....

.....

.....

.....

A.8.2.3 Using an example, describe how oxidation state can affect the light absorbed.

.....

.....

.....

.....

A.8.3 State that organic molecules containing a double bond absorb UV radiation. © IBO 2007

A.8.3.1 Molecules are selective about which photon energies of electromagnetic radiation they absorb. Organic molecules with only σ bonds absorb in the far UV range.

(a) Identify the feature of organic molecules that will cause them to absorb radiation in the ultraviolet range.

.....

.....

(b) Why does this feature cause absorption in the mid UV band rather than visible light?

.....

.....

.....

A.8.4 Describe the effect of the conjugation of double bonds in organic molecules on the wavelength of the absorbed light. © IBO 2007

A.8.4.1 What does the term 'conjugated double bonds' tell you about the structure of an organic compound?

.....

.....

.....

A.8.4.2 The information in the table below compares the wavelength of light absorbed in a spectrometer for two organic compounds.

Name	Ethene	Hexa-1,3,5-triene
Formula	$\text{CH}_2=\text{CH}_2$	$\text{CH}_2=\text{CH}-\text{CH}=\text{CH}-\text{CH}=\text{CH}_2$
Wavelength of light absorbed (nm)	171	258

Explain the difference in absorbed wavelengths in terms of the structure of the two compounds.

.....

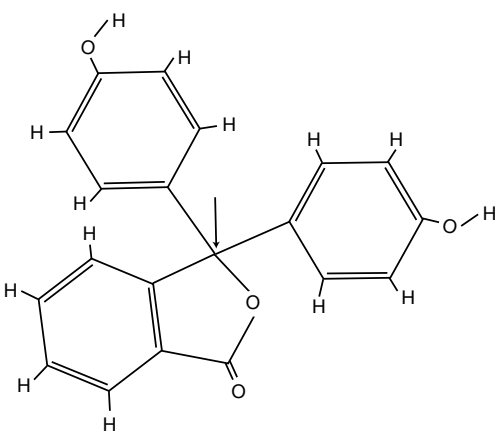
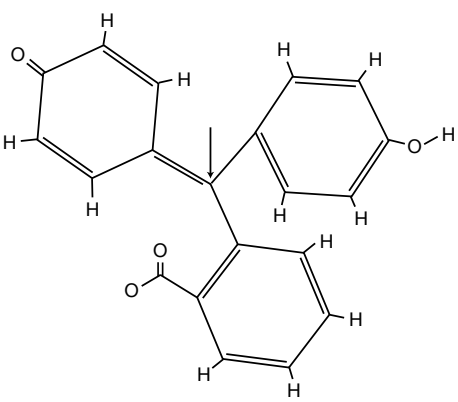
.....

.....

.....

.....

A.8.4.3 When the indicator phenolphthalein is placed in acidic and basic solution its structure changes and it changes colour as shown in the table below. The main change is in the structure around the carbon marked with an arrow. In basic solution, phenolphthalein loses two hydrogen ions and the molecule spreads and flattens.

Factor	Phenolphthalein in acidic solution	Phenolphthalein in basic solution
Diagram		
Light absorbed in a spectroscope	UV light	Blue/green visible light
Colour	Colourless	Red

Account for the changes in absorbance.

.....

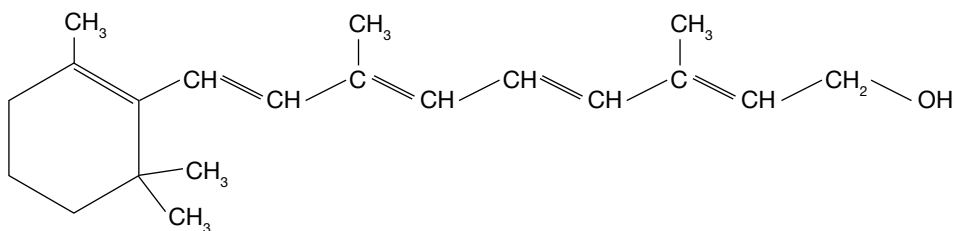
.....

.....

.....

.....

A.8.4.4 The diagram shows the structure of retinol, a form of vitamin A. Explain why this molecule appears yellow in colour.



.....

.....

A.8.4.5 From the labels on sunscreen protection products, choose two active ingredients. Research the structure of these ingredients and deduce the reason for their inclusion in the sunscreen.

.....

.....

.....

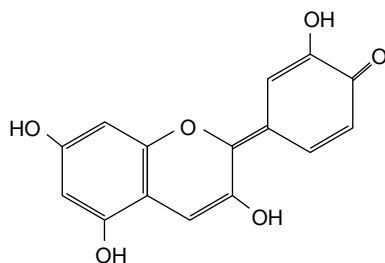
.....

.....

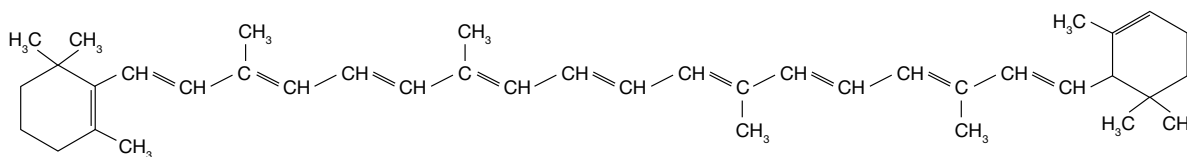
A.8.5 Predict whether or not a particular molecule will absorb UV or visible radiation. © IBO 2007

A.8.5.1 Predict whether each of the structures shown would absorb UV or visible radiation.

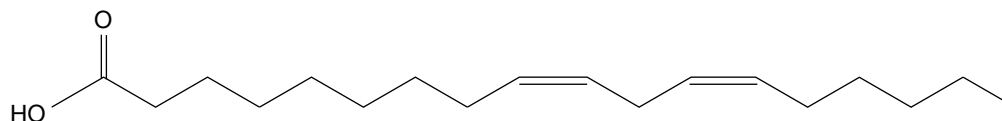
(a)



(b)



(c)



A.8.5.2 Outline the use of UV light absorption in detecting chemicals separated by column chromatography.

.....

.....

.....

.....

A.8.6 Determine the concentration of a solution from a calibration curve using the Beer-Lambert law. © IBO 2007

A.8.6.1

- (a) The Beer-Lambert law gives the relationship between concentration and absorption in spectroscopy. State this law (including the mathematical equation which summarises the relationship), clearly identifying each term.

.....

.....

.....

.....

.....

.....

.....

- (b) This law only holds true over a certain absorption range. What is this approximate range?

.....

.....

.....

A.8.6.2 Explain how a calibration curve is set up.

.....

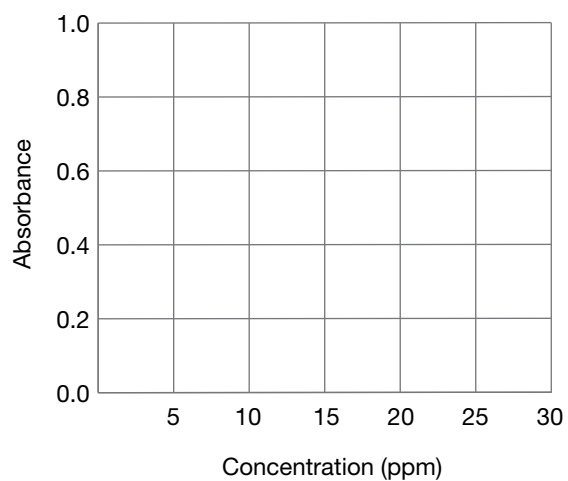
.....

.....

.....

A.8.6.3 Use the data provided to draw the calibration curve (a line of best fit) for phosphate and then use this curve to determine the concentration of a solution with absorbance of 0.3 units.

Absorbance	0	0.11	0.22	0.35	0.48	0.59	0.70
Phosphate concentration (ppm)	0	5	10	15	20	25	30



A.9.1 Explain the use of tetramethylsilane (TMS) as the reference standard. © IBO 2007

A.9.1.1 Nuclear magnetic resonance spectroscopy uses the effects of a magnetic field to provide information about the chemical environment of all the hydrogen atoms in molecules.

(a) Outline the effect of a magnetic field on the nuclei of hydrogen atoms.

.....

.....

.....

.....

.....

.....

.....

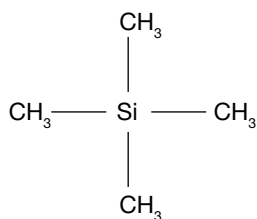
(b) Explain why a reference standard is needed in nuclear magnetic resonance spectroscopy.

.....

.....

.....

A.9.1.2 Explain why tetramethylsilane (TMS) is used as a reference standard.



Tetramethylsilane (TMS)

.....

.....

.....

.....

.....

A.9.1.3 Suggest reasons why tetraethylsilane $(\text{CH}_3\text{CH}_2)_4\text{Si}$ would not be an acceptable standard for ^1H NMR spectroscopy.

.....

.....

A.9.2 Analyse ^1H NMR spectra. © IBO 2007

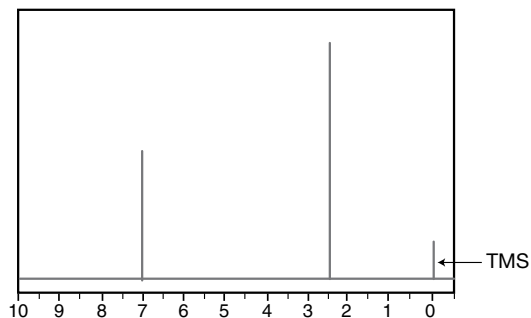
A.9.2.1 Complete the table to summarise information to be obtained from features of a ^1H NMR spectrum.

Feature	What it tells you
Number of peaks	
Area under the peaks	
The chemical shift	
Splitting of peaks	

A.9.2.2 The diagrams shows NMR spectra for two compounds. What can you deduce about the structure of these molecules from the spectra?

Use the chemical shift information from the data tables.

(a) A compound with molecular formula C_7H_{10} .



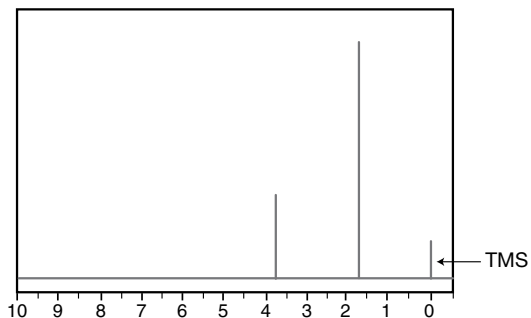
.....

.....

.....

.....

(b) A compound with molecular formula $\text{C}_4\text{H}_8\text{Cl}_2$.



.....

.....

.....

.....

A.9.2.3 In a high-resolution spectrum, each peak seen in the low-resolution spectrum may appear as a cluster of peaks.

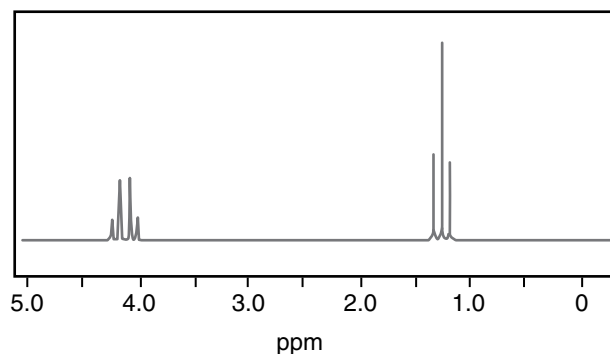
(a) What do we call a cluster with the following?

(i) 2 peaks

(ii) 3 peaks

(iii) 4 peaks

(b) The amount of splitting of each peak provides information about the number of hydrogens attached to the carbon(s) next to it. The diagram below shows part of a high-resolution spectrum. The cluster of peaks at 4.1 ppm represents a CH_2 group, and the cluster at 1.3 represents a CH_3 group. What does the splitting of these peaks tell you about the compound?



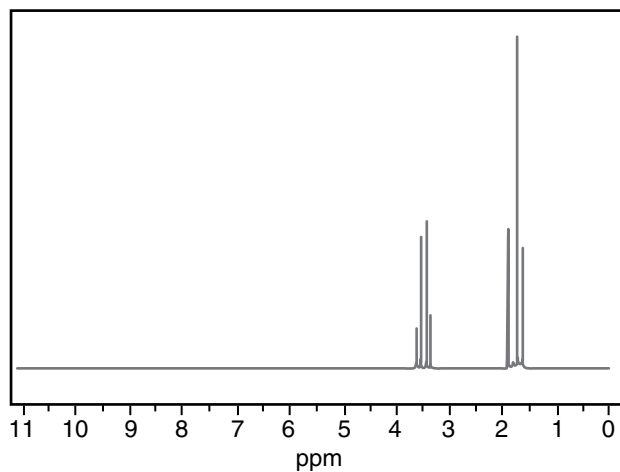
.....
.....
.....

(c) Explain why splitting of peaks occurs in high-resolution spectra.

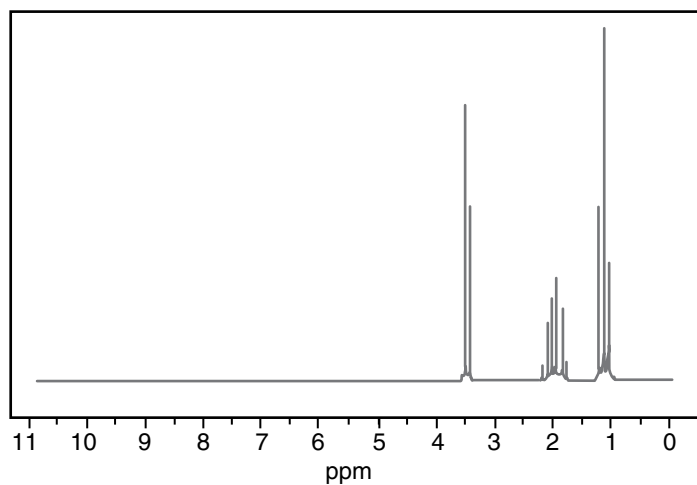
.....
.....
.....
.....
.....

A.9.2.4 The spectra below are for two compounds whose molecules each contain a bromine atom and a carbon chain. Identify the structure of the carbon chain in each compound.

(a)



(b)



A.10.1 Describe the techniques of gas-liquid chromatography (GLC) and high-performance liquid chromatography (HPLC). © IBO 2007

A.10.1.1 Gas-liquid chromatography is used to identify components in mixtures of volatile liquids that do not decompose at or near their boiling points.

(a) Describe the technique of gas-liquid chromatography (GLC).

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(b) Define retention time and identify factors which affect the retention time.

.....

.....

.....

.....

.....

A.10.1.2

(a) What do all forms of chromatography have in common?

.....

.....

(b) How does gas-liquid chromatography differ from all other forms of chromatography?

.....

.....

.....



A.10.1.3 High-performance liquid chromatography (HPLC) can be used to determine non-volatile components that decompose near their boiling points. Describe this technique.

.....

.....

.....

.....

A.10.1.4 Use a flow diagram to illustrate the process of HPLC.

A.10.2 Deduce which chromatographic technique is most appropriate for separating the components in a particular mixture. © IBO 2007

A.10.2.1 Outline an advantage and a disadvantage for high-performance liquid chromatography (HPLC).

.....

.....

.....

A.10.2.2 Suggest three applications appropriate for analysis by each of the following techniques.

(a) Gas-liquid chromatography (GLC).

.....

.....

.....

(b) High-performance liquid chromatography (HPLC).

.....

.....

.....

.....